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Estimating tourism-induced energy consumption and CO_2 emissions: The case of Cyprus

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ABSTRACT

The present study investigates the long-run equilibrium relationship among international tourism, energy consumption, and carbon dioxide emissions (CO_2), and the direction of causality among these variables in the case of a small island, Cyprus, which attracts more than 2 million international tourists every year. Results from "tourism-induced models" reveal that international tourism is in a long-run equilibrium relationship with energy consumption and carbon dioxide emissions; international tourist arrivals have positive, statistically significant, and inelastic impacts on the level of energy consumption and carbon dioxide emissons (which means negative impact for climate change). Error correction models reveal that carbon dioxide emission converges to its long-term equilibrium path by 95.4 percent speed of adjustment through the channels of tourism and energy consumption while, on the other hand, energy consumption converges to its long-term equilibrium path by 13.5 percent speed of adjustment through the channels of tourism and CO_2 emissions. Finally, the major finding from conditional Granger causality tests is that international tourism is a catalyst for energy consumption and for an increase in the level of carbon dioxide emissions in Cyprus.

Contents

1. Introduction

Searching for the link among energy consumption, climate change, and economic growth has drawn attention from researchers in energy economics. Among the latest studies in the field are Park and Hong [1], Zhang et al. [2], and Jayanthakumaran et al. [3]. However, the relationship of energy and climate change to specific segments or sectors of the economy deserves further attention. International tourism is one of them. Development of international

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tourism and more international tourists not only contribute to economies' income but also lead to an increase in energy consumption [4]. However, it is also likely that tourism development might have indirect effects on climate change through economic growth and energy capacity expansion. For example, an increase of tourism activities creates increased demand for energy at various functions such as transportation, catering, accommodation, and the management of tourist attractions [4–7], which is also likely to lead to environmental pollution and degradation. Liu et al. [4] suggests that transportation is a major contributor to energy consumption and carbon emissions in the tourism industry. On the other hand, Tsagarakis et al. [8] suggests that tourists from countries with higher energy awareness prove to be more willing to choose hotels with energy-saving installations and renewable energy sources. They argue that citizens from those countries (i.e. Canada, Japan, Sweden, and Finland) that adapt energy-saving policies successfully are more likely to prefer hotels with energy-saving installations in destination countries. In this respect, an investigation of the relationship among international tourism, energy consumption, and climate change will be of interest to both policy makers and practitioners. As also mentioned by Nepal [9], the World Summit on Sustainable Development in Johannesburg, South Africa, in 2002, has acknowledged international tourism as one of the major energy-consuming sectors. Nepal [9], Gössling [7], and Becken et al. [6] indicates that the transportation sector, especially air transportation, is responsible for the majority of energy consumption and resultant emissions from activities related to international tourism.

The existing literature of energy economics generally focuses on the link among economic growth, energy, and carbon emissions (as a proxy of environmental pollution), but results are still inconclusive see, for example, [10–19]. Some studies investigate the relationship between energy consumption and real income growth [10,20–22], some test the validity of the environmental Kuznets curve hypothesis (which deals with the relationship between environmental pollution and real income growth) [23–27], and some investigate the joint impact of energy consumption and environmental pollution on real income growth in the existing literature [18,28–31].

A relatively smaller strand of the literature studies the issue of energy consumption related to the tourism sector, mainly due to its implications for environmental issues, such as its contribution to climate change [6–7,32–34]. Only a few studies, on the other hand, focus on the link between tourism and electricity consumption see for instance, [5–8, 35–40]. The link among the energy sector, the environment, and international tourism has rarely been considered from different perspectives in the relevant literature. Tourism-related energy studies generally focus on estimating total energy use and efficiency [6], and comparison of energy consumption across different parts of tourism-related activities [9,37]. Nepal [9] finds that primary energy sources include wood and kerosene, but the use of renewable energy and locally developed energy-saving technologies increases in the tourism sector of Nepal. On the other hand, Gössling [7] estimates that global tourism-related energy consumption is 14,000 PJ. Of this amount, 94 percent comes from transportation, 3.5 percent to accommodation, and the remainder to the activities sector.

Since an increase in tourism and transportation activities comes with an increased demand for energy, the importance of energy for the tourism sector is beyond debate. In this respect, an investigation of the nature of the relationship among energy consumption, climate change, and tourism (including international transportation) is of interest to both policy makers and practitioners. It is expected that as tourism develops, it will start relying more on energy. Hence, it may lead to an increase in energy consumption. Furthermore, not only an increase in international tourist arrivals but also increased energy consumption may affect the environment or climate quality. It is evident that climate change is also likely to occur resulting from increased energy consumption due to tourism development through increased transportation (including air transportation) and construction of hotels and tourist establishments. But, initiatives that aim to reduce the energy intensity of tourism might prevent climate deterioration through energy consumption. However, to our knowledge, there exist very few studies exploring the econometric relationship among international tourism, climate change, and energy consumption in the relevant literature; among them is Lin [41] and Lee and Brahmasrene [42]. Specifically, Lee and Brahmasrene [42] find that tourism and FDI in the European Union countries create a high significant impact on CO_2 emissions. This issue deserves further attention from researchers.

1.1. Aim and importance of the present study

Against this backdrop, the present article employs bounds tests to level relationships, conditional error correction models, and conditional Granger causality tests to investigate long-run equilibrium relationships among international tourist arrivals, energy consumption, and carbon emissions in the south of Cyprus. This island enjoys a wide range of natural resources in terms of landscape, traditional folklore, gastronomy, culture, and a pleasant climate. Over the last 40 years, it has emerged as a major Mediterranean summer-sun destination [43,44]. The successful growth of international tourism underpinned a remarkable socio-economic development on the island [44–48]. The island attracts many international tourists, far more than its population every year.[3] Thus, it will be important to investigate the role of an expansion of international tourism in energy growth and climate change in Cyprus. It is important to mention that Cyprus has been a divided island since 1974; Greek Cypriots are accommodated in the south while Turkish Cypriots are accommodated in the north. This study focuses on the south of Cyprus in order to investigate empirical relationships among tourism, energy, and carbon emissions.

The rest of the article is structured as follows. Section 2 defines the theoretical setting of the present study; Section 3 introduces the data and methodology; Section 4 presents the empirical results and discussions, and Section 5 concludes the study.

2. Theoretical setting

The CO_2 (carbon dioxide) emissions (kt) have been used as a proxy for climate change in the energy studies of the relevant literature. Many studies also have linked CO_2 and energy consumption see [1–3,50–53] among others. The starting point of the theoretical setting in the present study is that international tourist arrivals might be a determinant of energy consumption and CO_2 emissions too. Thus, the following "tourism-induced" functional relationships have been put forward in the present study:

$$CO_{2t} = f\,(T_t, E_t) \tag{1}$$

$$E_t = f\,(T_t,\ CO_2) \tag{2}$$

where CO_2 is a proxy for climate change in (kt), T is international tourist arrivals, and E is energy use (kt of oil equivalent). Eqs. (1) and (2) will be estimating tourism-induced CO_2 emissions and energy consumption, respectively. Many authors have incorporated CO_2 and E variables together as regressors in order to predict

[3] The number of international tourists visiting Cyprus was well above 2 million in 2010 [49].

some other variable such as real income. For example, Alam et al. [50] have adopted dynamic modeling of causal relationship among energy consumption, CO_2 emissions, and real income growth. When, for example, real income is dependent-variable, energy consumption and CO_2 emissions are taken as regressors; on the other hand, when, for example, energy consumption is dependent-variable, then real income and CO_2 emissions are taken as regressors; therefore, the concept of proposed functions in Eqs. (1) and (2) of the present study is parallel to those in the literature such as Alam et al. [50].

The functional relationships in Eqs. (1) and (2) can be expressed in logarithmic form to capture the growth impacts in the economic long-term period [54]:

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln T_t + \beta_2 \ln E_t + \varepsilon_t \tag{3}$$

$$\ln E_t = \beta_0 + \beta_1 \ln T_t + \beta_2 \ln CO_{2t} + \varepsilon_t \tag{4}$$

where at period t, $\ln CO_2$ is the natural log of CO_2 emissions; $\ln E$ is the natural log of energy consumption; $\ln T$ is the natural log of the international tourism variable; and ε is the error disturbance.

The dependent variables in Eqs. (3) and (4) may not immediately adjust to their long-run equilibrium levels following a change in any of their determinants [54]. Therefore, the speed of adjustment between the short-run and the long-run levels of dependent variables can be captured by estimating the following error correction models:

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta \ln CO_{2t-j} + \sum_{i=0}^{n} \beta_2 \Delta \ln T_{t-j} + \sum_{i=0}^{n} \beta_3 \Delta \ln E_{t-j} + \beta_4 \varepsilon_{t-1} + u_t \tag{5}$$

$$\Delta \ln E_t = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta \ln E_{t-j} + \sum_{i=0}^{n} \beta_2 \Delta \ln T_{t-j} + \sum_{i=0}^{n} \beta_3 \Delta \ln CO_{2t-j} + \beta_4 \varepsilon_{t-1} + u_t \tag{6}$$

where Δ represents a change in the CO_2, E, and T variables and ε_{t-1} is the one period lagged error correction term (ECT), which is estimated from Eqs. (3) and (4). The ECT in Eqs. (5) and (6) show how fast the disequilibrium between the short-run and the long-run values of the dependent variable is eliminated each period. The expected sign of ECT is negative see [55].

3. Data and methodology

3.1. Data

The data used in this paper are annual figures covering the period 1970–2009. The variables of the study are the total number of international tourists arriving and staying in tourism establishments in the south of Cyprus (T), energy use (E), and carbon dioxide emissions (CO_2). Data of tourist arrivals have been obtained from the Statistical Service of Cyprus [49] while data of energy use and CO_2 have been obtained from the World Bank Development Indicators [56]. As mentioned in the previous section, the natural logarithm of all variables have been used in econometric analysis in order to capture growth impacts of regressors on the dependent variable.

There are several alternatives to measure tourism variables in the literature, as also mentioned by Katircioglu [57]. These include tourism receipts, the number of nights spent by visitors from abroad, and the number of international tourist arrivals. The tourism variable of the present study was proxied by the number of international tourists who visit Cyprus and stay in the tourist establishments. On the other hand, in parallel to previous works in energy literature, the energy consumption variable in the present study is proxied by overall energy use (kt of oil equivalent) and the climate change variable is proxied by the overall CO_2 emissions (kt).

3.2. Unit root tests

Kwiatkowski Phillips, Schmidt, and Shin's unit root test [58] (KPSS) has been used in the present study, which is suggested to eliminate a possible low power against stationary near unit root processes that occurs in the augmented Dickey Fuller (ADF) [59] and Phillips–Perron (PP) [60] unit root tests. The null hypothesis of the KPSS test is that a series is stationary. This means that a stationary series is likely to have insignificant KPSS statistics.

3.3. Bounds tests

To investigate the long-run relationship among the variables under consideration, the bounds test within ARDL (the autoregressive distributed lag) modeling approach was adopted. This approach was developed by Pesaran et al. [61] and can be applied irrespective of the order of integration of the variables (irrespective of whether regressors are purely I [0], purely I [1] or mutually co-integrated). The ARDL modeling approach involves estimating the following error correction model:

$$\Delta \ln CO_{2t} = a_0 + \sum_{i=1}^{n} b_i \Delta \ln CO_{2t-i} + \sum_{i=0}^{n} c_i \Delta \ln T_{t-i} + \sum_{i=0}^{n} d_i \Delta \ln E_{t-i} + \sigma_1 \ln CO_{2t-i} + \sigma_2 \ln T_{t-i} + \sigma_3 \ln E_{t-1} + \varepsilon_{1t} \tag{7}$$

$$\Delta \ln E_t = a_0 + \sum_{i=1}^{n} b_i \Delta \ln E_{t-i} + \sum_{i=0}^{n} c_i \Delta \ln T_{t-i} + \sum_{i=0}^{n} d_i \Delta \ln CO_{2t-i} + \sigma_1 \ln E_{t-i} + \sigma_2 \ln T_{t-i} + \sigma_3 \ln CO_{2t-1} + \varepsilon_{2t} \tag{8}$$

In Eqs. (7) and (8), Δ is the difference operator; $\ln Co_{2t}$ is the natural log of carbon dioxide emissions, $\ln T_t$ is the natural log of tourist arrivals; $\ln E_t$ is the natural log of energy consumption; ε_{1t} and ε_{2t} are serially independent random errors with mean zero and a finite covariance matrix.

Again, in Eqs. (7) and (8), the F-test is used for investigating a (single) long-term relationship. In the case of a long-term relationship, the F-test indicates which variable should be normalized. In Eqs. (7) and (8), the null hypothesis of no level relationship is H_0: $\sigma_1 = \sigma_2 \times \sigma_3 = 0$ and the alternative hypothesis of a level relationship is H_1: $\sigma_1 \neq \sigma_2 \neq \sigma_3 \neq 0$ [52].

In the case of level relationships in Eqs. (7) and (8), the conditional ECM using the ARDL approach will be employed in this study in order to estimate the short-term coefficients and the ECM term. Furthermore, as also suggested by Pesaran et al. [61], the time series properties of the key variables (CO_2, T, and E) in the conditional ECM of the present study can be approximated by double-log error correction at lag levels that might be different for each explanatory variable, augmented with appropriate deterministics such as intercept and time trend. Eqs. (5) and (6) of the present study will be used to estimate the conditional error correction model where β_4 is the coefficient of the error correction term and expected to be negative, as mentioned earlier. Finally, the dependent variable in the ARDL models needs to be integrated of order one, I (1), [61].

3.4. Granger causality tests

In the case of level relationships based on the bounds test, conditional Granger causality tests should be carried out under the error correction model. By doing so, the short-run deviations of the series from their long-run equilibrium path are also captured by including an error correction term. Therefore, conditional error

correction models (that use the ARDL approach) for Granger causality in this study can be specified as follows:

$$\begin{bmatrix} \Delta CO_{2t} \\ \Delta T_t \\ \Delta E_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \end{bmatrix} + \begin{bmatrix} \partial_{11,1} & \partial_{12,1} & \partial_{13,1} \\ \partial_{21,1} & \partial_{22,1} & \partial_{23,1} \\ \partial_{31,1} & \partial_{32,1} & \partial_{33,1} \end{bmatrix} \begin{bmatrix} \Delta CO_{2t-1} \\ \Delta T_{t-1} \\ \Delta E_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} \partial_{11,i} & \partial_{12,i} & \partial_{13,i} \\ \partial_{21,i} & \partial_{22,i} & \partial_{23,i} \\ \partial_{31,i} & \partial_{32,i} & \partial_{33,i} \end{bmatrix} \begin{bmatrix} \Delta CO_{2t-i} \\ \Delta T_{t-i} \\ \Delta E_{t-i} \end{bmatrix} + \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \end{bmatrix} \times ECT_{t-1} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} \tag{9}$$

In Eq. (9), Δ denotes the difference operator. ECT_{t-1} is the lagged error correction term derived from the long-run model in Eqs. (3) and (4). Finally, $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, and $\varepsilon_{3,t}$, are serially independent random errors with mean of zero and a finite covariance matrix. Finally, according to the conditional ECM for causality tests, having statistically significant t-ratios for ECT_{t-1} in Eq. (9) would meet the conditions for having long-term causations, while significant F-ratios for the overall models in the same equation would denote short-term causations.

4. Results and discussions

One of the underlying assumptions of classical linear regression models is that series are stationary with a fixed mean, variance, and covariance. Therefore, the stationary nature of the series should be investigated prior to further analyses. Table 1 gives unit root test results for the variables under consideration. The KPSS

Table 1
KPSS test for unit root.

Statistics (Level)	ln$T$	Lag	lnCO_2	Lag	ln$E$	Lag
η_t	0.195**	(4)	0.147**	(2)	0.133***	(4)
η_u	0.683***	(5)	0.775*	(5)	0.765*	(5)
Statistics (First difference)	ln$T$	Lag	lnCO_2	Lag	ln$E$	Lag
η_t	0.080	(5)	0.024	(2)	0.104	(3)
η_u	0.222	(4)	0.065	(2)	0.138	(9)

Notes: (1) η_t and η_u represent constant and trend in the model. (2) Numbers in brackets are lag lengths indicating the lag truncation for Bartlett Kernel suggested by Newey–West [63]. (3) Critical values are taken from Kwiatkowski et al. [58]. (4) Tests for unit roots have been carried out in EVIEWS 6.0.

* Denote the rejection of the null hypothesis at 1 percent.
** Denote the rejection of the null hypothesis at 5 percent.
*** Denote the rejection of the null hypothesis at 10 percent.

Table 2
Critical values for the ARDL modeling approach (n=40).
Source: Narayan [64] for F-statistics and Pesaran et al. [61] for t-ratios.

	0.10		0.05		0.01	
k=2	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
F_{IV}	3.663	4.378	4.360	5.138	5.980	6.973
F_V	4.477	5.420	5.387	6.437	7.527	8.803
F_{III}	3.373	4.377	4.133	5.260	5.893	7.337
t_V	−3.130	−3.630	−3.410	−3.950	−3.960	−4.530
t_{III}	−2.570	−3.210	−2.860	−3.530	−3.430	−4.100

Notes: (1) k is the number of regressors for dependent variable in ARDL models, F_{IV} represents the F statistic of the model with unrestricted intercept and restricted trend, F_V represents the F statistic of the model with unrestricted intercept and trend, and F_{III} represents the F statistic of the model with unrestricted intercept and no trend. (2) t_V and t_{III} are the t ratios for testing $\sigma_1 = 0$ in Eqs. (7) and (8) with and without deterministic linear trend.

Table 3
The bounds test for level relationships.

Variables	With deterministic trends F_{IV}	F_V	t_V	Without deterministic trend F_{III}	t_{III}	Conclusion
(1)						H_0
F_{CO_2}(lnCO_2/ln$T$, ln$E$)						
p=1[a]	10.266[e]	12.771[e]	−3.924[e]	–	–	Rejected
2[b]	5.021[e]	5.597[e]	−2.782[c]	4.894[e]	−2.177[c]	
3	4.861[e]	5.614[e]	−0.824[c]	3.132[c]	−0.602[c]	
4	3.500[c]	4.120[c]	0.333[c]	1.820[c]	−0.388[c]	
5	–	–	–	2.813[c]	−2.763[d]	
(2)						
F_E (ln$E$/ln$T$, lnCO_2)						
p=4*	10.152[e]	11.284[e]	−0.029[c]	12.533[e]	−1.683[c]	Rejected
5	3.205[c]	4.269[c]	1.023[c]	2.895[c]	−1.391[c]	
6	0.975[c]	1.099[c]	0.196[c]	1.256[c]	−0.898[c]	
7	2.035[c]	1.987[c]	1.807[c]	0.944[c]	−0.461[c]	

[a] Denotes optimum lag selection in each model as suggested by SC, and
[b] Denotes optimum lag selection in F_{III} scenario for the first model as suggested by SC. F_{IV} represents the F statistic of the model with unrestricted intercept and restricted trend, F_V represents the F statistic of the model with unrestricted intercept and trend, and F_{III} represents the F statistic of the model with unrestricted intercept and no trend. t_V and t_{III} are the t ratios for testing $\sigma_1 = 0$ in Eqs. (7) and (8) with and without deterministic linear trend.
[c] Indicates that the statistic lies below the lower bound.
[d] That it falls within the lower and upper bounds.
[e] That it lies above the upper bound.

[58] test suggests tourist arrivals to Cyprus (T), CO_2 emissions, and energy use (E) are nonstationary at their levels but become stationary at first differences. The tests have been run from general to specific models as also suggested by Enders [62]. To summarize, T, CO_2, and E variables are said to be integrated of order one, I (1), in the present study.

Although series are found to be I (1) in the present study, there is a possibility that they might still be cointegrated (in co-movement). Therefore, in the next step, bounds tests to level relationships will be employed to investigate the long-run equilibrium relationship among international tourist arrivals, energy consumption, and CO_2 emissions in two separate "tourism-induced" models defined in Eqs. (3) and (4). Bounds tests through the ARDL modeling approach are suggested by Pesaran et al. [61]. Critical values for F statistics (for n=40 observations in the present study) are presented in Table 2 as taken from Narayan [64]. Table 3 gives the results of the bounds tests for level relationships in two different models where international tourism is assumed to be a determinant of CO_2 in the first model and of energy consumption in the second model. These two models are run under three different scenarios as suggested by Pesaran et al. [61], which are with restricted deterministic trends (F_{IV}), with unrestricted deterministic trends (F_V) and without deterministic trends (F_{III}). Intercepts in these scenarios are all unrestricted.[4]

Results in Table 3 show that the application of the bounds F-test using the ARDL modeling approach suggest level relationships since the null hypothesis of H_0: $\sigma_1 = \sigma_2 = \sigma_Y = 0$ of Eqs. (7) and (8) can be rejected; conclusions from all the scenarios (F_{III}, F_{IV} and F_V) enable us to reject this hypothesis. Therefore, international tourist arrivals to Cyprus are said to be in a level relationship with CO_2 emissions in Eq. (3) and with energy consumption in Eq. (4). There is co-movement among tourist arrivals, energy consumption, and CO_2 emissions. The results from the application of the bounds t-test in the ARDL model allow for imposing a deterministic trend only in the first model where CO_2 emissions are dependent-variable since t_V ratio is statistically significant [see

[4] For detailed information, please refer to Pesaran et al. [61], 295–296.

Table 4
Conditional error correction estimations under the ARDL approach.

Dependent variable: CO_2 Lag structure: (5, 0, 1) (With deterministic trend)				Dependent variable: E Lag structure: (4, 0, 4) (Without deterministic trend)			
Regressor	Coefficient	Standard error	p-value	Regressor	Coefficient	Standard error	p-value
$\hat{u}_{t-1}$	−0.954	0.154	0.000	$\hat{u}_{t-1}$	−0.135	0.017	0.000
$\Delta \ln CO_{2t-1}$	0.314	0.138	0.031	$\Delta \ln E_{t-1}$	−0.401	0.131	0.005
$\Delta \ln CO_{2t-2}$	0.230	0.122	0.069	$\Delta \ln E_{t-2}$	−0.551	0.111	0.000
$\Delta \ln CO_{2t-3}$	0.138	0.084	0.111	$\Delta \ln E_{t-3}$	−0.204	0.087	0.027
$\Delta \ln CO_{2t-4}$	0.209	0.083	0.069	$\Delta \ln T$	0.093	0.011	0.000
$\Delta \ln T$	0.003	0.024	0.901	$\Delta \ln CO_2$	0.299	0.057	0.000
$\Delta \ln E$	1.002	0.179	0.000	$\Delta \ln CO_{2t-1}$	0.265	0.082	0.003
Intercept	−0.001	0.012	0.934	$\Delta \ln CO_{2t-2}$	0.351	0.074	0.000
				$\Delta \ln CO_{2t-3}$	0.281	0.080	0.001
				Intercept	0.000	0.006	0.991
Adj. R^2=0.692, S.E. of Regr.=0.030, AIC=−3.966, SBC=−3.611, F-stat.=11.917, F-prob.=0.000, $D-W$ stat.=2.094				Adj. R^2=0.929, S.E. of Regr.=0.016, AIC=−5.174, SBC=−4.734, F-stat.=52.528, F-prob.=0.000, $D-W$ stat.=1.859			

61:312]. Therefore, results reached from F_{IV} and F_V scenarios are also said to be robust where a deterministic trend is included in these models.

Level relationships in the bounds tests have been investigated in the present study. These level relationships for Eqs. (3) and (4) allow for the adoption of the ARDL approach to estimate the level coefficients as also discussed in Pesaran and Shin [65]. The resulting estimates of level relationships under the ARDL specification for Eq. (3) (where CO_2 is dependent-variable) (lags: 5, 0, 1) and Eq. (4) (where energy consumption is dependent-variable) (lags: 4, 0, 4) are given below (numbers in brackets are p-values):

CO_2 emissions—International tourism/energy consumption relationship in Eq. (3):

$$\ln CO_{2t} = \underset{(0.002)}{0.033}\,(\ln T_t) + \underset{(0.000)}{0.642}\,(\ln E_t) - \underset{(0.000)}{5.515} + \hat{u}_t$$

Energy consumption—International tourism/CO_2 emissions relationship in Eq. (4):

$$\ln E_t = \underset{(0.030)}{0.619}\,(\ln T_t) + \underset{(0.060)}{0.801}\,(\ln CO_{2t}) + \underset{(0.000)}{6.328} + \hat{u}_t$$

The above estimations show that tourist arrivals have a positive and statistically significant impact on CO_2 emissions and energy consumption. For example, as can be seen from the first long-term model, a 1 percent change in the tourism variable will lead to 0.033 percent change in CO_2 emissions in the same direction. The impact of tourism is higher for energy consumption (0.619). CO_2 emissions and energy consumption also have positive and statistically significant interactions in the long-term period. Intercept in the case of Eq. (3) is negative and statistically significant (−5.515) as expected, which reveals that when there is not any change in tourism and energy consumption variables, CO_2 emissions are likely to decline by 5.515 percent.

In the next stage, conditional ECM regressions associated with the level relationships as defined in Eqs. (3) and (4) should be estimated. The ECM estimations from Eqs. (5) and (6) are provided in Table 4.

The ECT terms in Eqs. (5) and (6) are (respectively, −0.954 and −0.135) statistically significant and negative.[5] Results of Table 4 implies that CO_2 emissions converge to its long-term equilibrium level by 95.4 percent speed of adjustment through the channels of international tourist arrivals and energy consumption; and that energy consumption converges to its long-term equilibrium level by 13.5 percent speed of adjustment through the channels of international tourist arrivals and CO_2 emissions. The speed of adjustment in Eq. (5) is higher. Although the long-term coefficient of the tourism variable in the model when CO_2 emission is dependent-variable is statistically significant, the short-term coefficient of the tourism variable is not statistically significant in the ECM (in Eq. (5)) as presented in Table 4. It is important to mention that having a statistically significant long-term impact of the tourism variable on CO_2 emissions is a sufficient condition to assume tourism development as a determinant of climate change through increases in energy use.

As a final step, the direction of causality can now be searched within the conditional Granger causality tests under the ARDL mechanism. F-statistics for short-term causations and t-statistics of ECTs for long-term causations are given in Table 5 as estimated from Eq. (9).

Results reveal two unidirectional causalities in the long-term period that run (1) from international tourism and energy consumption to CO_2 emissions and (2) from international tourism and CO_2 emissions to energy consumption.[6] These results prove that international tourist arrivals to Cyprus are a catalyst for energy consumption and carbon emissions (climate change), which suggest that a change in tourist arrivals will precede changes in energy consumption and carbon dioxide emissions in the long-term period. This finding is in parallel with the findings of Lee and Brahmasrene [42]. On the other hand, F tests from Table 5 also reveal some short-term causations among tourism, energy consumption, and CO_2 emissions: (1) Bidirectional causality between energy consumption and CO_2 emissions, which is parallel to the results of many previous literature studies. (2) unidirectional causality that runs from CO_2 emissions to tourist arrivals; (3) unidirectional causality that runs from energy consumption to tourist arrivals. Short-term causality tests suggest that there is a feedback relationship between energy consumption and carbon emissions in Cyprus, and that higher energy consumption not only will result in higher economic growth (as documented in the literature) but also in a higher number of tourist arrivals in the short-term period.

[5] ECT terms should be negative by expectation.

[6] This is because t statistics of the ECTs in Eq. (9), where respectively CO_2 emissions and energy consumption are dependent-variable, and are statistically significant in Table 5.

Table 5
Condional Granger causality tests under the ARDL approach.

	F-statistics [probability values]			
Dependent variable	$\Delta \ln CO_{2t}$	$\Delta \ln T_t$	$\Delta \ln E_t$	*t*-stat (prob) for ECT_{t-1}
Panel (a) Conditional Granger causality between CO_2 emissions and international tourism (with deterministic trend)				
$\Delta \ln CO_{2t}$	–	1.059 [0.416]	2.352*** [0.085]	−2.538* [0.021]
$\Delta \ln T_t$	3.711** [0.018]	–	14.440* [0.000]	−0.573 [0.574]
$\Delta \ln E_t$	2.057 [0.121]	0.582 [0.712]	–	−1.043 [0.311]
	F-statistics [probability values]			
Dependent variable	$\Delta \ln E_t$	$\Delta \ln T_t$	$\Delta \ln CO_{2t}$	*t*-stat (prob) for ECT_{t-1}
Panel (b) conditional Granger causality between energy consumption and international tourism (with intercept)				
$\Delta \ln E_t$	–	1.292 [0.312]	3.737** [0.018]	−2.390** [0.028]
$\Delta \ln T_t$	1.761 [0.174]	–	2.781*** [0.051]	−1.030 [0.317]
$\Delta \ln CO_{2t}$	1.795 [0.167]	0.968 [0.464]	–	−1.223 [0.237]

* Denote the rejection of null hypothesis respectively at alpha 0.01.
** Denote the rejection of null hypothesis respectively at alpha 0.05.
*** Denote the rejection of null hypothesis respectively at alpha 0.10.

5. Conclusion

This paper empirically investigated the long-term equilibrium relationship and the direction of causality among international tourism, energy consumption, and climate change in Cyprus. Justification of doing this research is that climate change and the energy sector are likely to be affected by international tourist arrivals. Two tourism-induced models have been proposed in the present study: In the first model, tourist arrivals and energy consumption are in a level relationship with the dependent variable of carbon dioxide emissions; in the second model, tourist arrivals and carbon dioxide emissions are also in a level relationship with the dependent variable of energy use (consumption). Tourism has a direct and statistically significant impact on the level of carbon dioxide emissions and energy consumption in the long-term period of the Cypriot economy; this impact is higher for energy consumption. Error correction models in the present study have shown that (1) carbon dioxide emission converges to its long-term equilibrium path by 95.4 percent speed of adjustment through the channels of tourism and energy consumption, which is very high and deserves attention. This finding reveals that tourism growth significantly enables climate change to move at high levels. And (2) energy consumption converge to its long-term equilibrium path but at a lower rate (13.5 percent) through the channels of tourism and carbon dioxide emissions. As confirmed by conditional Granger causality tests under the ARDL approach, a change in tourism stimulates changes in carbon dioxide emissions and energy consumption.

The major finding of the present study from econometric analysis is therefore that tourist arrivals are a catalyst for energy consumption and therefore climate change in the long term of the Cyprus economy. This study has also found that increases in energy consumption not only result in economic growth but also result in growth in the number of international tourist arrivals to Cyprus in the short term.

The results of the present study suggest that when the Cypriot government sets measurements for environmental protection (controlling climate changes), the international tourism sector should be seriously taken into consideration. Protection measurements in the tourism sector should be set. Sustainability in the tourism sector is one of the major focuses in the debate on environmentally integrated tourism development [9]. As also investigated from Nepal [9], tourism-induced energy demand poses a threat not only at the local level but also at the global level, which affects the global climate. This study has proved that tourism growth plays an important role in forcing energy consumption and carbon dioxide emissions in the case of Cyprus; therefore, this message should not be understated by the authorities. A message goes to the authorities at the global level as well, since suggestions from the literature for environmental protection within the international tourism sector are focused on only local aspects, whereas implications to resolve global impacts of tourism are significantly lacking see also [9,34].

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